# LOW-GRADE MAGNETITE DEPOSITS NEAR FISH LAKE, MT. HAYES QUADRANGLE, ALASKA

By James C. Barker

With a section on Local Geology and Petrography by K. A Hill, and
a section on Geophysics by Louise Pellerin.

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Field Report

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

## ILUSTRATIONS--Continued



## TABLES

## UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

| | | | |
|---|---|---|---|
| cm | centimeter | mm | millimeter |
| ft | foot | m yr | million years |
| g | gram | pct | percent |
| in | inch | t oz | troy ounce |
| wt pct | weight percent | | |

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By James C. Barker[1]

With a section on Local Geology and Petrography by K.A. Hill,[2]

and a section on Geophysics by Louise Pellerin[3]

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## ABSTRACT

In 1983, the Bureau of Mines made a routine mineral investigation of the Fish Lake Ultramafic Complex in the east-central Alaska Range. The investigation was originally intended to evaluate reserve potential of chromium, cobalt, and platinum-group metals, however during the course of the study relatively significant low-grade, chromic magnetite deposits were found. Samples from these deposits averaged 12.9 pct $Fe_3O_4$ and 0.27 pct chromium. Subparallel zones of magnetite stockworks occur in serpentinite and appear to be associated with regional thrust faulting. The best exposed zone varies in width from 200 to 800 ft and is exposed intermittently along a strike length of one mile.

Concentration tests indicated an average recovery of 63 pct at minus 150-mesh grind size. Magnetic concentrates averaged 58 pct magnetite and 1.2 pct elemental chromium. Concentration ratios were nearly identical for both iron and chromium; 1:4.5 for $Fe_3O_4$ and 1:4.4 for chromium. A solid solution chromiun + iron spinel (chromic magnetite) appears to account for the similar concentration ratios during the magnetic concentration. At 150-mesh size some magnetite remained locked in olivine and was not leachable during acid digestion. Finer grinding should improve magnetite recovery and concentrate grade.

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[3]Geophysicist, Arctic Technical Research, Inc., Fairbanks, Ak.

The magnetite stockwork zones can be inferred to contain substantial tonnages of chromium and iron as a resource. However, the recoverable grade of the chromium magnetite is too low for the product to be suitable as a source of either metal.

## INTRODUCTION

In 1983, the Bureau of Mines made a mineral reconnaissance evaluation of ultramafic rocks comprising the Fish Lake Complex, located near Fish Lake in the east-central Alaska Range (fig. 1). The investigation focused on the verbal reports by the U.S. Geological Survey (USGS), which suggested potential for chromium, cobalt, nickel, and the platinum-group metals. During the investigation, however, low-grade magnetite mineralization was discovered to be relatively significant.

Field studies were performed in July and August of 1983, and totaled six staff-days of work. Work consisted of geologic mapping, geochemical sampling, chip sampling for metallurgical tests, and a ground magnetic survey. The majority of the time was spent on the western side of Fish Lake where the complex is better exposed and magnetite mineralization is more abundant. A total of 22 pan concentrate, rock, rock chip, and stream sediment samples were collected for analysis. Ground magnetic data was collected along 11,600 ft of survey line.

The objective of this report is to present analytical data and describe the magnetite occurrences and their geologic setting in the Fish Lake Complex.

Sections of this report on Geology and Petrography, by K. A. Hill, and on Geophysics, by Louise Pellerin, were done under contract agreement between the Bureau of Mines and Arctic Technical Research, Inc., of Fairbanks, AK. This report specifically addresses the ultramafic units within the map area west of Fish Lake and the western portion of the ultramafic units to the east of Fish Lake (fig. 2). The potential for cobalt, nickel, and PGM will be included in a later report.

## PREVIOUS WORK

Rocks of the Fish Lake area have been the subject of several geologic investigations. They were first described in detail by Rose in 1966 (1)[4].

[4]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

Geologic mapping at 1:63,360 scale of the area was completed by J. H. Stout of the Alaska Division of Geological and Geophysical Surveys (ADGGS) in 1976 (2).

The ADGGS also published a regional aeromagnetic contour map in 1973 (3). In 1978 and 1979, W. J. Nokleberg of the U.S. Geological Survey (USGS) remapped the geology of the area at a scale of 1:63,360 and reduced this mapping to a 1:250,000 scale (4). An intensely serpentinized area northwest of Fish Lake that was mapped but not described, by Nokleberg, is the subject of this report.

Mineral resource potential of the Fish Lake area was addressed during a 1982 symposium on the Mt. Hayes Quadrangle sponsored by the USGS[5].

[5]Studies by the USGS are part of the Alaskan Mineral Resource Appraisal Program (AMRAP), W. J. Nokleberg, project manager, Menlo Park, CA. A summary of geology and mineral resources of the Mt. Hayes Quadrangle was presented at the symposium, March 16, 1982, Anchorage, Ak.

The Fish Lake Complex was described as a cumulate mafic-ultramafic body of considerable thickness with potential for chromium, cobalt, nickel, and PGM mineralization. No specific mineral occurrences were reported, however.


## ACKNOWLEDGEMENTS

Several individuals aided in obtaining data for this report. Testing and evaluation of magnetite samples was done under the direction of Dr. P. D. Rao, Mineral Industry Research Laboratory, University of Alaska, Fairbanks, AK.

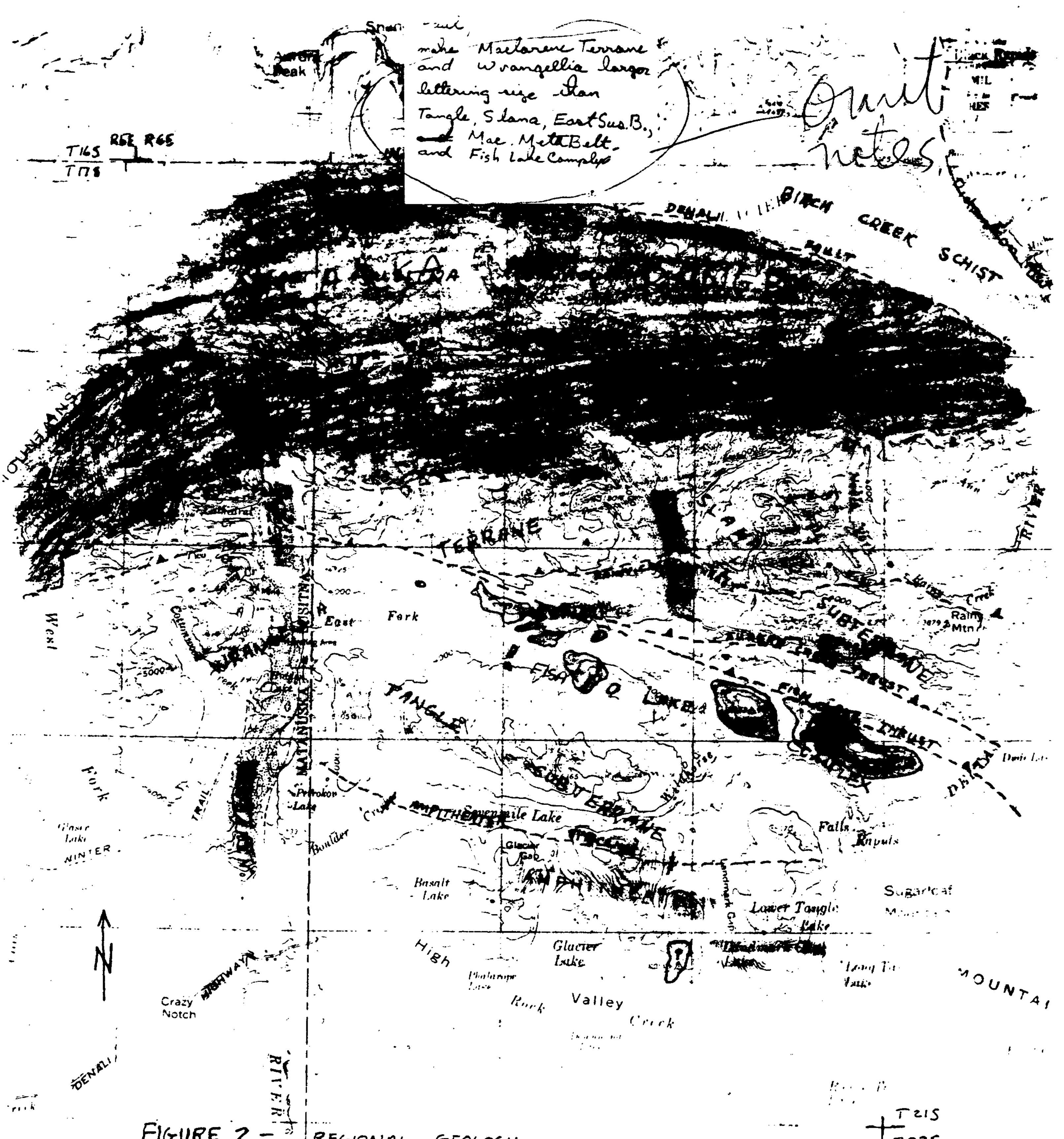



FIGURE 2 – REGIONAL GEOLOGY

— — — Fault inferred

▲ – ▲ Thrust fault inferred

Syncline

FISH LAKE COMPLEX

☐ Olivine cumulate; peridotite of the Fish Lake Complex

■ Olivine pyroxene cumulate; pyroxenite of the Fish Lake Complex

Scale 1:250,000, 1 inch = 4 miles

Geology adapted from Nokleberg and others, 1982(-) and Stout 197(-)

Topographic base adapted from Mt. Hayes Quadrangle

Mineralogical work and X-ray emission spectrography (XES) testing on sample 15 was performed by J. Drake, Geologist, Bureau of Mines, Juneau, Ak. E. Harris, geologist, formerly of the Bureau of Mines, Fairbanks, AK, assisted with the geological mapping. T. L. Pittman, Mining Engineer, Bureau of Mines, Juneau, AK, provided technical advice and critically reviewed the manuscript.

## LOCATION AND ACCESS

The magnetite deposits near Fish Lake are located in the east-central Alaska Range (fig. 1), in the northeast corner of the Mt. Hayes A-5 (1:63,360) quadrangle. Fish Lake is approximately 20 air miles north-west of Paxson and 11 air miles west of Summit Lake and the Richardson Highway. The area is easily accessible by foot, helicopter, or float plane.

## PHYSIOGRAPHY

The report area is characterized by rounded tundra-covered hills that protrude within a large intermontane basin. Elevations range from 3,100 to 4,372 ft giving a relief of about 1,300 ft. Bedrock exposure above 3,500 ft elevation is good but generally limited to rubble. Tundra and glacial till cover the lower elevations. The area was glaciated in Wisconsin and older glaciations; alpine glaciers extended from the Alaska Range to the north. Ground moraine has been mapped in the report area by Stout (2).

## REGIONAL GEOLOGY

The Fish Lake area is underlain by a complex sequence of lithologically and tectonically distinct wedges of rock strata that have been juxtaposed along regional thrust and strike-slip faults (4) (fig. 2). Nokleberg and others (4) subdivided the region into two tectonostratigraphic terranes, the Maclaren terrane to the north and the Wrangellia terrane to the south. The Maclaren terrane consists of fault-bounded slices of Jurassic(?) argillite, and metagraywacke, phyllite, and schist that have been intruded by the

70 m.y.-old and older East Susitna Batholith. The Tangle subterrane of the Wrangellia terrane, to the south, consists of a thin sequence of upper Paleozoic sedimentary and tuffaceous rocks unconformably overlain by a thick sequence of Triassic Nikolai Greenstone composed of pillow lavas and subaerial basalt flows. These rocks were originally mapped by Stout (2) as the Amphitheater Group. Finally, the Slana River subterrane of the Wrangellia terrane, exposed in fault slices between the Tangle subterrane and the Maclaren terrane, consists of a thick sequence of upper Paleozoic volcanic, volcanoclastic, and sedimentary rocks disconformably overlain by a thin sequence of the Triassic Nikolai Greenstone. The Triassic Fish Lake Complex of ultramafic and mafic rocks has intruded strata of the Tangle subterrane and is interpreted to be comagmatic with the Nikolai (4). This Complex comprises a series of outcropping peridotite, pyroxenite, and gabbro bodies that trend northwest from near Fish Lake to the Maclaren Glacier. Age of the Complex was proposed to be Jurassic(?) (2) but more recently suggested to be Triassic (4).

The Fish Lake Complex is bounded to the north by the Fish Lake Thrust fault (4). Prominent topographic linears both north and south of the ultramafic bodies and along Eureka Creek suggest the complex also is bounded by other northwest-trending faults.

Similar ultramafic and mafic rocks can be found in the area south of the Fish Lake Thrust fault, though their structural relationship to the Fish Lake Complex is uncertain. Stout (2) reported peridotite rocks southwest of Landmark Gap Lake, approximately eight miles to the south of Fish Lake. Nokleberg (4) located a serpentinite body about 28 miles northwest of Fish Lake and on strike with the Fish Lake Complex

## PROCEDURES

Geologic mapping and a ground survey were completed at a 1 in to 1,760 ft (1:21,120) scale. A vertical field fluxgate magnetometer, a Brunton compass, and a hip chain were used for the magnetic survey.

Stream sediment and panned concentrate samples were obtained with a steel shovel from silty gravels taken from the center of the active creek channels. For stream sediment samples, approximately 0.5 lb of finer grain sediment was placed directly into water-resistant paper bags, and later air-dried, and screened at minus 80 mesh. The minus 80-mesh fraction was then pulverized prior to standard atomic absorption analyses. Panned concentrates were collected with a 14-in (35.6 cm) pan which was heap-filled and carefully panned until nearly all quartz, feldspar, and mafic minerals were removed. Three pans of material were reduced and the total concentrate composited at each sample location. Each composite heavy mineral fraction was air-dried in the laboratory and pulverized for analyses by fire assay - Inductively Coupled Plasma (ICP) methods.

Rock chip samples of the magnetite-bearing zones consist of randomly chosen rock chips collected along a 50-ft interval of grid line. Samples were each about 10 lbs in size. Head analyses (crushed sample prior to beneficiation) are listed in table 1. Estimates of magnetite content of the chip samples were made in two ways: the first was by an acid-soluble iron leach of a head sample (table 1); the second by a Davis-tube separation[6]

[6]Inclined glass tube which makes a wet magnetic separation while agitating a sample pulp through a low intensity electromagnet.

followed by an acid-soluble iron analysis of the magnetic and non-magnetic

Table 1. - Analytical results of magnetite chip head samples

| Sample[1] | As, ppm | Au, tr oz/ton | Co, ppm | Cr, pct | $Fe_3O_4$, pct[2] | Mg, pct | Mn, pct | P, pct | Pd, tr oz/ton | Pt, tr oz/ton | S, pct | Si, pct | Ti, pct | V, ppm | Zn, ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3...... | ND | ND | 120 | 0.10 | 13.5 | 22 | 0.17 | ND | ND | ND | 0.08 | 17 | 0.096 | ND | ND |
| 9...... | ND | ND | 55 | .29 | 11.9 | 23 | .13 | ND | ND | ND | .02 | 11 | .22 | ND | ND |
| 10..... | ND | ND | 81 | .26 | 13.3 | 22 | .12 | ND | ND | ND | .01 | 13 | ND | ND | ND |
| 11..... | ND | ND | 200 | .38 | 11.6 | 22 | .13 | ND | ND | ND | .02 | 16 | .23 | ND | ND |
| 12..... | ND | ND | 215 | .18 | 12.0 | 16 | .16 | ND | ND | ND | .03 | 21 | 1.0 | ND | ND |
| 13..... | ND | ND | 70 | .34 | 13.5 | 22 | .14 | ND | ND | ND | .06 | 14 | .094 | ND | ND |
| 14..... | ND | ND | 225 | .32 | 12.7 | 22 | .13 | ND | ND | ND | .05 | 14 | ND | ND | ND |
| 15..... | ND | ND | 170 | .32 | 12.4 | 24 | .14 | ND | ND | ND | .01 | 17 | .80 | ND | ND |

ND - Not detected.

[1]Samples were scanned for Ir, Os, Rh, and Ru and none was detected.

[2]$Fe_3O_4$ calculated from analytical results for acid-soluble iron.

fractions (table 2). Procedures used for determination of the acid-soluble iron and the calculation of the magnetite content of the chip samples are presented by illustration (fig. 6) later in this report. Analyses of trace and minor elements in the Davis-tube concentrates are shown in table 3.

Rock specimens were also collected for petrographic study and geochemical analysis. Portions of these rocks were pulverized and analyzed for arsenic, cobalt, copper, nickel, vanadium, and zinc by atomic absorption procedures. Analyses for gold and PGM were done by fire assay-ICP and analysis for the remaining elements was done by X-ray fluorescence. Rock descriptions are based on thin section examinations. The magnetite was examined in polished thin sections and polished grain mounts.

## LOCAL GEOLOGY AND PETROGRAPHY

By K. A. Hill

### Lithology

The Fish Lake Complex comprises southeast striking serpentinites (Sp), peridotites (Pe), which locally grade to dunite, and olivine pyroxenites (Pp), which locally include mafic pyroxene gabbro (fig. 3, back pocket). The serpentinite unit contains mappable zones of magnetite stockworks (Sz) and all the rocks at Fish Lake exhibit simple cumulate layering. Younger gabbro and rhyodacite dikes (Rd) cut the ultramafic units.

The ultramafic and altered rock units are readily distinguishable in the field. The serpentinite (Sp) is light gray to black and weathers to a spotty rust and rusty-orange color, and commonly is highly fractured. The serpentinite with stockworks unit (Sz) (fig. 4) is generally a gray-green color with black criss-crossing veinlets of magnetite and aphanitic serpentine. The peridotite (Pe) is dark gray to black and weathers to a dun color.

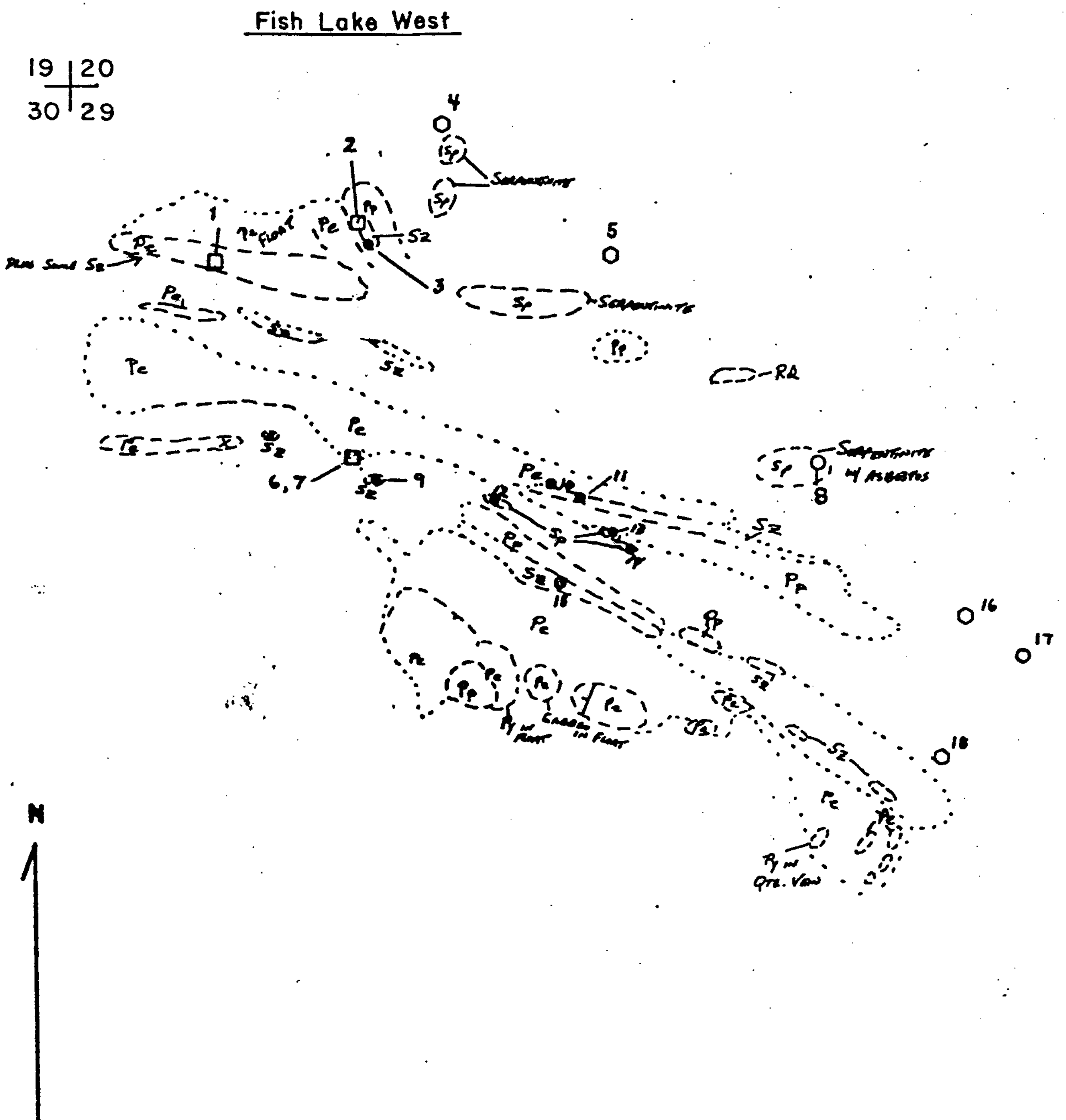



FIGURE 3. - Local geology and sample locations near Fish Lake.

Figure 3. - Local geology and sample locations near Fish Lake.

## DESCRIPTION

Pe - Olivine cumulate; peridotite, and dunite

Pp - Olivine pyroxene cumulate; pyroxenite and mafic pyroxene gabbro

Sp - Serpentinite

Sz - Sp with magnetite stockwork zone

Rd - Rhyodacite and gabbro dike

---- Inferred contact or limit of outcrop and rubble-crop exposures

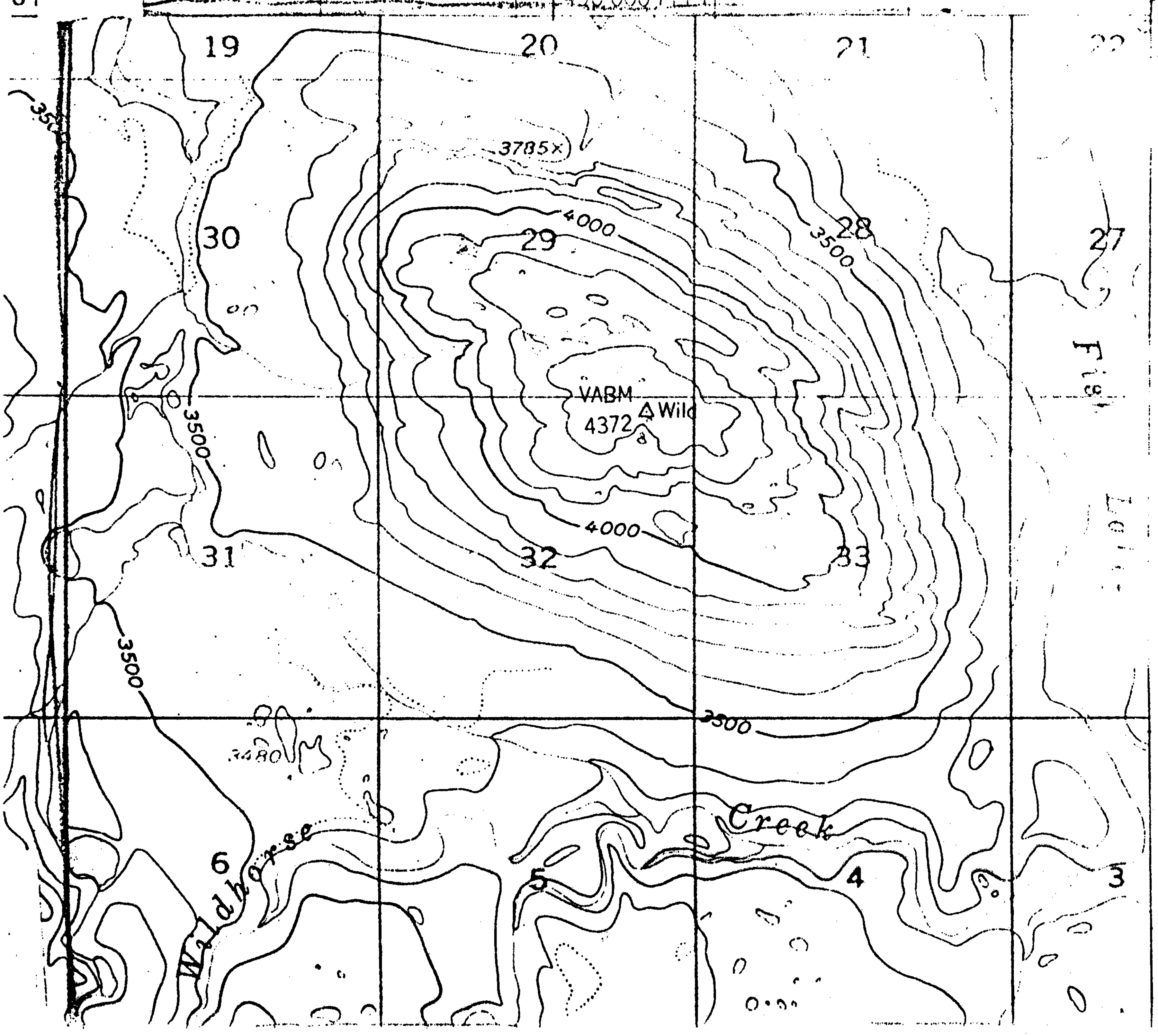
.... Limit of float and talus of indicated rock unit. Inferred extent of Sz also based on ground magnetic survey.

SCALE: 1 " = 1760'

- Pan concentrate sample
- Stream sediment sample
- Rock sample
- Chip sample across 50-ft interval

Mapping by: J. Barker, E. Harris, & K. Hill

July & Aug., 1983.




The topography on these two sheets will be composited to provide a base for figure 3.

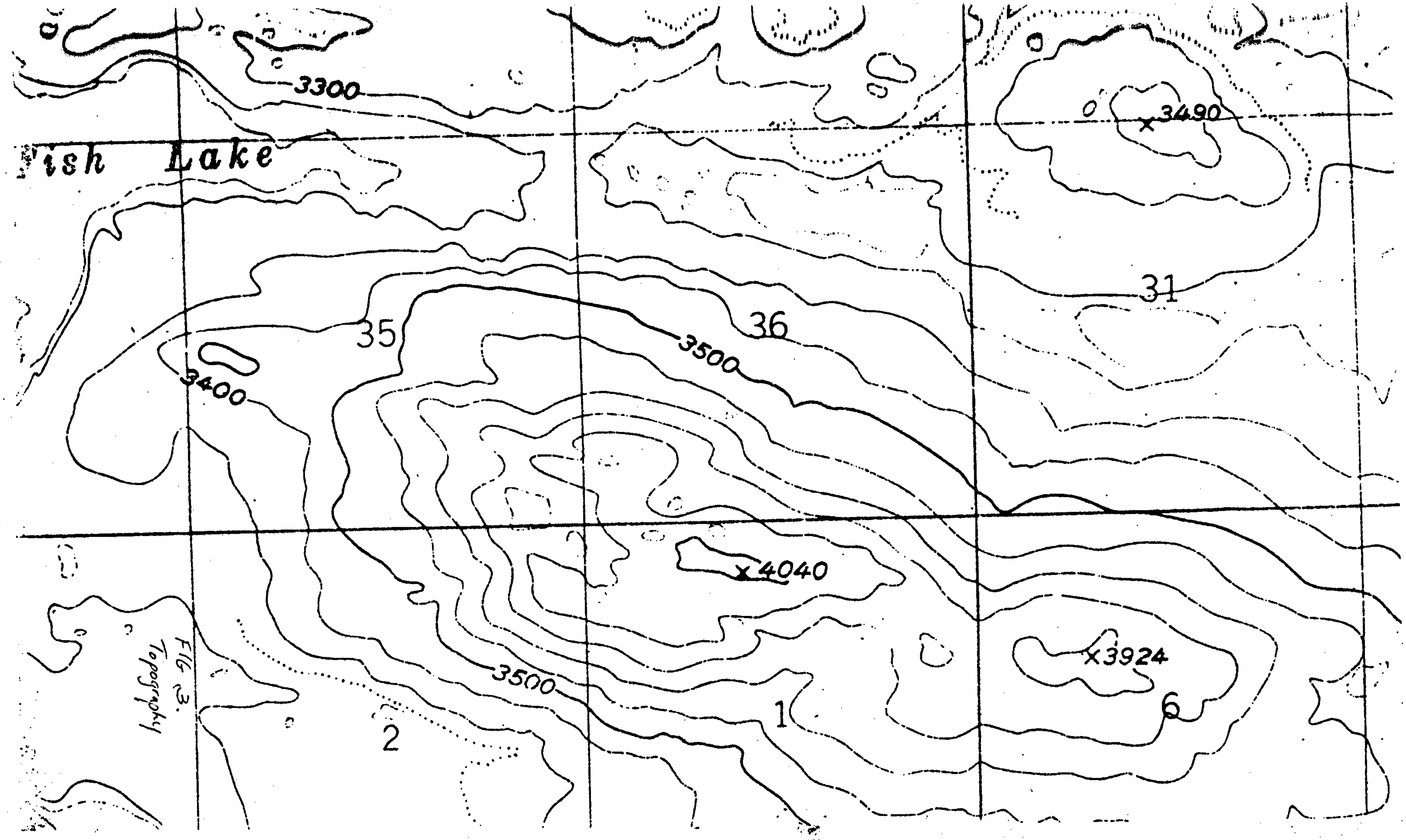



FIG 3. Topography

Table 2. - Magnetic separation test results

| Sample | Product | Wt g | Wt pct | Fe, pct Analysis | Fe, pct Distribution | Wt pct Magnetite |
|---|---|---|---|---|---|---|
| 3....... | Magnetics........ | 0.42 | 4.2 | 37.7 | 15.8 | 52.1 |
| | Non-magnetics.... | 9.58 | 95.8 | 8.8 | 84.2 | 12.2 |
| | Head (calc.)..... | 10.00 | 100.0 | 10.0 | 100.0 | 13.8 |
| 9....... | Magnetics........ | 1.25 | 12.5 | 46.8 | 67.0 | 64.7 |
| | Non-magnetics.... | 8.75 | 87.5 | 3.3 | 33.0 | 4.6 |
| | Head (calc.)..... | 10.00 | 100.0 | 8.7 | 100.0 | 12.0 |
| 10...... | Magnetics........ | 1.26 | 12.6 | 47.9 | 63.9 | 66.2 |
| | Non-magnetics.... | 8.74 | 87.4 | 3.9 | 36.1 | 5.4 |
| | Head (calc.)..... | 10.00 | 100.0 | 9.4 | 100.0 | 13.0 |
| 11...... | Magnetics........ | 1.23 | 12.3 | 50.8 | 71.1 | 70.2 |
| | Non-magnetics.... | 8.77 | 87.7 | 2.9 | 28.9 | 4.0 |
| | Head (calc.)..... | 10.00 | 100.0 | 8.8 | 100.0 | 12.2 |
| 12...... | Magnetics........ | 5.23 | 17.4 | 35.9 | 69.0 | 49.6 |
| | Non-magnetics.... | 24.77 | 82.6 | 3.4 | 31.0 | 4.7 |
| | Head (calc.)..... | 30.00 | 100.0 | 9.1 | 100.0 | 12.6 |
| 13...... | Magnetics........ | 1.35 | 13.5 | 51.3 | 67.8 | 70.9 |
| | Non-magnetics.... | 8.65 | 86.5 | 3.8 | 32.2 | 5.3 |
| | Head (calc.)..... | 10.00 | 100.0 | 10.2 | 100.0 | 14.1 |
| 14...... | Magnetics........ | 1.77 | 17.7 | 34.6 | 66.8 | 47.8 |
| | Non-magnetics.... | 8.23 | 82.3 | 3.7 | 33.2 | 5.1 |
| | Head (calc.)..... | 10.00 | 100.0 | 9.2 | 100.0 | 12.7 |
| 15...... | Magnetics........ | 2.30 | 23.0 | 29.9 | 73.6 | 41.3 |
| | Non-magnetics.... | 7.70 | 77.0 | 3.2 | 26.4 | 4.4 |
| | Head (calc.)..... | 10.00 | 100.0 | 9.3 | 100.0 | 12.8 |

Note.--Head (calc.) magnetite values were determined by acid-soluble analyses of magnetic fractions recovered in a Davis Tube.

TABLE 3. - Analytical results of magnetite concentrates

| Sample | Cr, pct | Mn, pct | P, ppm | S, pct | Si, pct | Ti, pct | Zn, ppm |
|---|---|---|---|---|---|---|---|
| 3..... | 0.68 | 0.19 | <400 | NA | 10.0 | 0.55 | 660 |
| 9..... | 1.8 | .20 | <200 | .066 | 4.4 | .71 | 290 |
| 10.... | 1.6 | .20 | <200 | .062 | 4.3 | .33 | 190 |
| 12.... | .96 | .20 | <200 | .055 | 6.4 | 1.7 | 190 |
| 13.... | 1.2 | .21 | <200 | .11 | 5.0 | .25 | 180 |
| 14.... | 1.1 | .15 | <200 | .14 | 9.0 | .25 | 210 |
| 15.... | 1.0 | .16 | <200 | .022 | 5.0 | .47 | 84 |

NA - Not analyzed.

Note.--Arsenic (As) determinations were attempted, but analytical results are uncertain due to interference. Sample 3 had detectable As. Sample 11 was insufficient for analyses.

Figure 4. Serpentinite with magnetite stockworks.

Locally, Pe contains pyroxene phenocrysts giving the weathering surface a "hobnail" appearance. Olivine grains are usually less than or equal to 1 mm in size. A calculated 1.3 MgO:SiO2 ratio by X-ray emission spectrography on sample 15 indicates a forsteritic olivine. Stout (2) also cited olivine (Fo80-90) present in dunite near Fish Lake. Pyroxene in the Pp appears to be augite.

## Alteration

Olivine is altered to some degree to serpentine and magnetite throughout the map area. The serpentine is mostly antigorite, though chrysotile veinlets were noted. Magnetite occurs as finely disseminated euhedral to subhedral grains throughout the rock, in concentrations along the stockwork veinlets (fig. 5), and in web-like patterns within olivine grains.

To the northwest of Fish Lake, serpentinite has been pervasively altered to elongated magnetite stockwork zones (Sz) (fig. 4). Petrographic estimates of magnetite (Fe3O4) content of rock specimens in these zones range from 10 to 30 pct. The disseminated magnetite content of the surrounding rock units increases near the Sz. About 5 pct or less disseminated fine-grained (<0.5 mm) magnetite and a trace of very fine-grained (<0.1 mm) pyrite was ubiquitous in the ultramafic units. Minor amounts (up to a few percent) of an unidentified, nonmagnetic iron spinel are also disseminated in the Sz. It could not determined, however, whether this is a primary or an alteration mineral.

In 1976, Stout (2, p.23) noted the development of complete serpentinization near the covered contacts with the country rock, but did not specify particular locations. Serpentinization of the inner portions of the ultramafic units was found to be less. The contact of the intrusion with metasedimentary and volcanic rocks was not observed in the map area (fig. 3) because of vegetation and glacial till which mantle the lower elevations to the north.

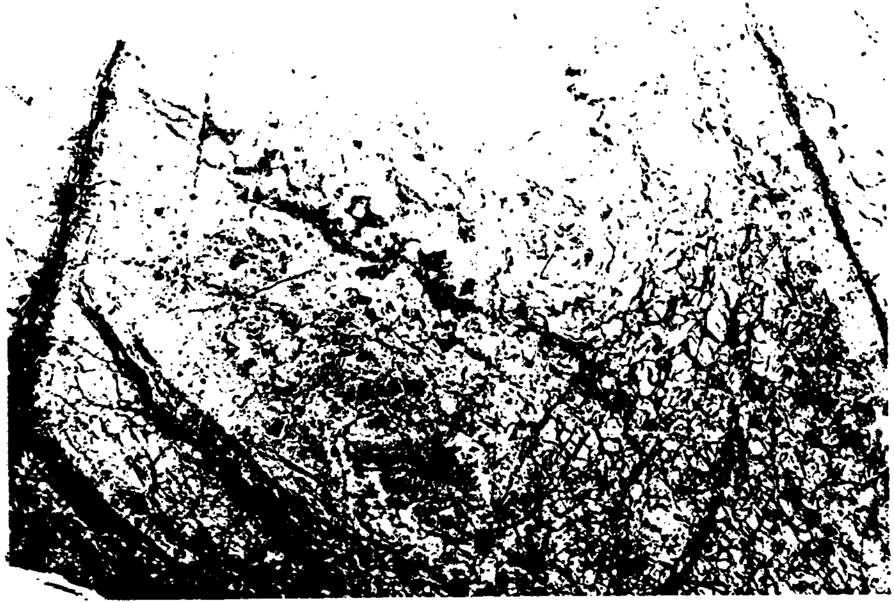


Figure 5. - Photomicrograph of disseminated and stockwork magnetite in serpentinite of the Sz unit. Note for scale the photograph is 3 cm across.

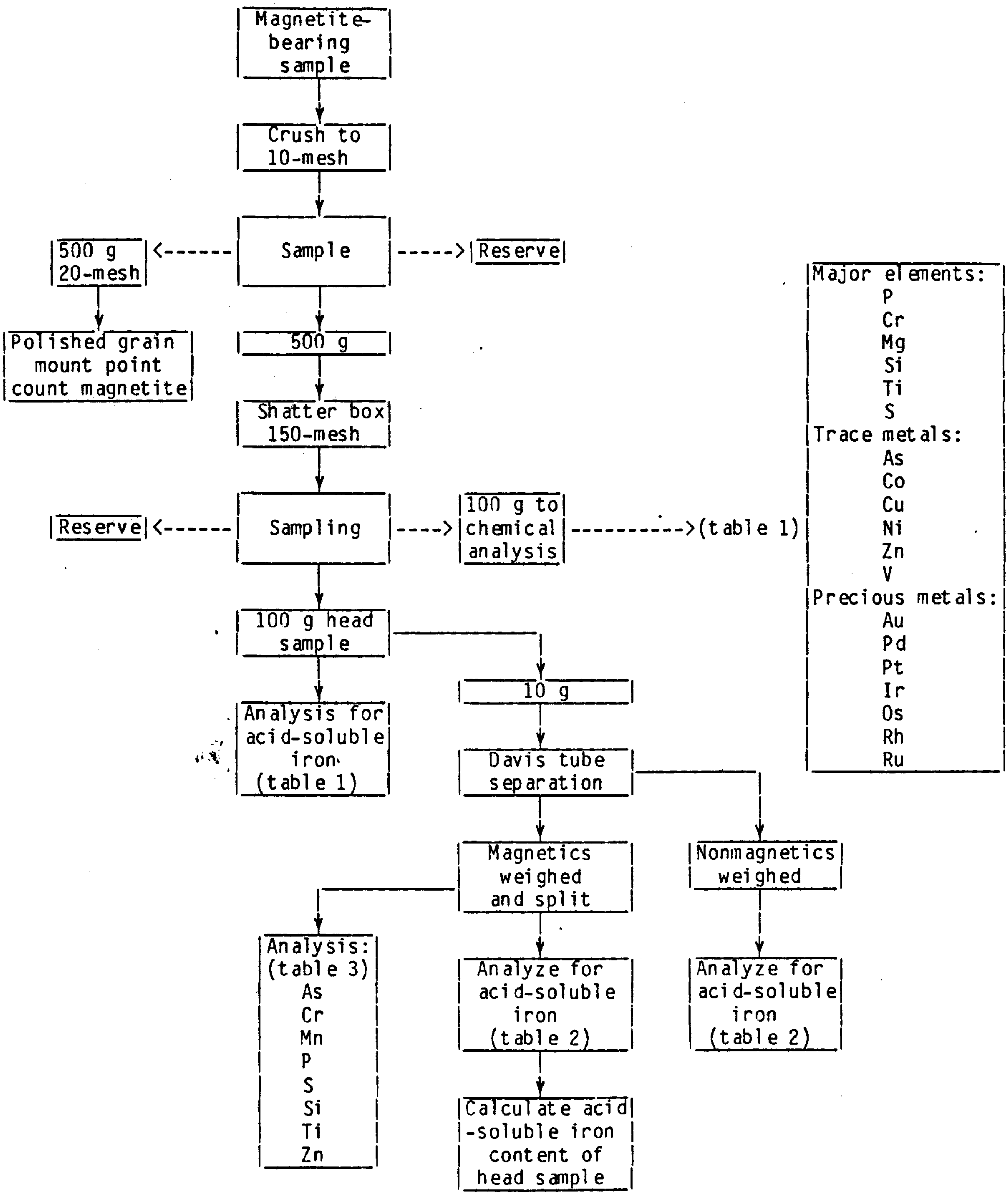



FIGURE 6. - Flowsheet for processing magnetite chip samples

The pyroxene has altered to hornblende in some areas. Chlorite and sericite also occur as alteration products of the pyroxenes, particularly along some fractures.

### Structure

The dominant structural element of the Fish Lake Complex is the northwest-trending Fish Lake Thrust fault which borders the Complex to the north. The contacts of the peridotite and pyroxenite units, the serpentinite-magnetite stockwork bodies, and the pervasive jointing, are similarly oriented northwesterly and subparallel to the regional strike. The rock units both east and west of Fish Lake display a somewhat schistose texture, especially within the more altered units.

## MINERALIZATION AND METALLURGY

The highest magnetite content is found within intermittently exposed stockwork zones (fig. 3). The best exposed zone is 4,000 to possibly 5,300 ft long and ranges in width from 200 to 800 ft. There appears to be a southeasterly-trending spur zone which is intermittently traced for about 5,000 ft. Additionally, at least two poorly exposed Sz zones occur to the north. The depths of the zones are unknown, however, topographic relief provides exposures over about 350 ft of elevation. Chip samples of the Sz zones were collected from 50-ft line intervals as shown in figure 3. The mode of occurrence of magnetite is described in the previous section (figs. 4-5).

The Davis-tube tests (fig. 6) on crushed chip samples gave calculated magnetite content of head samples between 12.0 and 14.1 pct with an average of 12.9 pct. Magnetite content of the concentrates averaged 58 pct by weight. This magnetic separation resulted in a concentration ratio of 1:4.5. Recovery ranged between 16 and 74 pct, averaging 63 pct. Microscopic examination of the tailings (the non-magnetic fraction) showed that recovery losses are due to extremely fine-grained unliberated magnetite latticed within the olivine grains.

Two samples were also analyzed by the American Standard Testing Methods (ASTM) point count techique (table 4). Analysis by point count method utilized a polished section of head sample which had been crushed to minus 20 mesh pelletized in epoxy.

Table 4. - Point count determination of magnetite content

(Weight percent)

| Sample | Silicate gangue | Magnetite | Other opaques |
|---|---|---|---|
| 11........ | 83.1 | 11.9 | 5.0 |
| 15........ | 79.1 | 18.1 | 2.8 |

NOTE. - Specific gravities used for weight percent calculations:
Silicate gangue 3.45
Magnetite and other opaques 5.17.

Point count results were in close agreement with the magnetite estimates obtained from the Davis tube test (table 2) on sample 11. The discrepancy between the above results of sample 15 is probably due to concentrations of minute magnetite grains and those in table 2 enclosed within serpentine and therefore unavailable for attack in acid digestion. This further indicates that the percent of magnetite in the Sz zones is somewhat greater that the average 12.9 pct determined from table 2.

The head samples averaged 0.27 pct Cr (table 1). The upgrading of chromium content from 0.27 pct in head samples to an average 1.2 pct Cr in the magnetite concentrates resulted in a chromium concentration ratio of 1:4.4 which was nearly identical to the concentration ratio of the magnetite and indicates a chromium-iron solid solution spinel. The spinel can be termed a chromic magnetite. Residual grains remaining after acid digestion of the magnetite accounted for 5 to 10 pct of the concentrate. These were in order of abundance, and unidentified nonmagnetic iron spinel,[7] unliberated magnetite, and traces of an iron-nickel alloy and arsenopyrite. Chromite was sought but not found.[7]

[7]Microprobe examination provided by J. Sjoberg, Bureau of Mines Reno (NV) Research Center.

Some mineralogic zoning may exist between different Sz zones. Sample 3 was the only sample collected from the northern-most Sz zone. As noted in table 1, this sample contained the lowest chromium content (0.10 pct) of any of the chip samples, as well as slightly higher levels of manganese and sulfur. Sample 3 contained the only detectable arsenic (table 3) and as illustrated in table 2, the poorest iron recovery was achieved in the Davis tube concentrate of this sample.

Pyrrhotite, pentlandite, chalcopyrite, magnetite, and pyrite were observed in peridotite float at sample sites 6 and 7 (table 5). The extent of this occurrence could not be determined because of rubble cover. The pentlandite and pyrrhotite are fine- to medium-grained ($\leq$5 mm) and total about 4 pct combined. Trace chalcopyrite, rare pyrite, and up to 3 pct magnetite are associated with the iron-nickel sulfide mineralization. The magnetite forms a web-like texture within altered olivine grains.

TABLE 5. - Analytical results of rock specimens

| Sample[1] | Au, tr oz/ton | Co, ppm | Cr, ppm | Cu, ppm | Fe, pct | Mn, ppm | Ni, ppm | Pd, tr oz/ton | Pt, tr oz/ton |
|---|---|---|---|---|---|---|---|---|---|
| 1...... | NA | ND | NA | 490 | 7.3 | NA | 570 | NA | NA |
| 2...... | ND | 180 | NA | NA | NA | NA | NA | ND | ND |
| 6...... | NA | 186 | NA | 2,080 | NA | NA | 2,280 | 0.002 | 0.002 |
| 7...... | NA | 165 | [2]5,000 | [2]700 | [2]10 | 2,000 | 1,500 | NA | NA |

NA - Not analyzed.
ND - Not detected.
[1]Samples were scanned for Ir, Os, Rh, and Ru and none was detected.
[2]Analyzed by semi-quantitative emission spectrography.

## Sample Description

1 - Grab sample of coarser grained phase of peridotite with normal background disseminated magnetite.

2 - 15-ft chip sample across iron-stained serpentinite with magnetite stockworks and accessory chrysotile.

6 - Grab sample of serpentinized peridotite with magnetite and pyrrhotite-pentlandite (4 to 5 mm) anhedral grains with associated finely disseminated ($\leq$0.4 mm) chalcopyrite.

7 - Similar to sample 6.

Stream sediment data suggest similar mineralization occurs near sample site 8 (table 6).

Panned concentrate samples were collected to determine if gold, platinum, or palladium may be associated with the Fish Lake Complex. Only traces of gold and no platinum or palladium were detected (table 7).

## GEOPHYSICS

By Louise Pellerin

The ADGGS aeromagnetic contour map (3) clearly defines a strongly magnetic region approximately 20 miles in length extending northwest from about three miles southeast of Fish Lake to the Maclaren Glacier (fig. 7). A series of magnetic highs along this continous trend suggest large bodies varying in magnetic response; the strongest response was recorded east of Fish Lake with field strength decreasing to the northwest. A magnetic high also occurs in the area where Nokleberg (4) mapped a serpentinite body (about 28 miles northwest of Fish Lake) but this does not appear to be a continuation of the Fish Lake Complex.

A reconnaissance ground investigation employing a vertical field fluxgate magnetometer was made in the vicinity of the magnetite-serpentinite stockwork northwest of Fish Lake near an aeromagnetic anomaly of 6,500 gamma. Figure 8 shows the geophysical survey lines and anomalous areas where the vertical field strength exceeds 59,000 gammas. A traverse (line 'c', fig. 8) perpendicular to the northwest-trending geologic contact of pyroxenite and peridotite was made to establish a magnetic signature. Fifty-foot station spacing on line 'a' revealed a series of sharp peaks spanning several thousand gammas. This is interpreted as a near-surface zone of stringers or pods of high-grade magnetic mineral concentration. Response on line 'a' infers

TABLE 6. - Analytical results of stream sediment samples, ppm.

| Sample | Ag, | Au, | Co, | Cu, | Ni, | Pb, | Zn, |
|---|---|---|---|---|---|---|---|
| 8..... | ND | ND | 260 | 410 | 2,100 | ND | ND |
| 17.... | ND | ND | 74 | 140 | 650 | ND | ND |
| 19.... | ND | ND | 34 | 76 | 490 | ND | 14 |
| 21.... | ND | ND | 43 | 110 | 470 | ND | ND |

ND - Not detected.

TABLE 7. - Analytical results of panned concentrate samples, t oz/ton

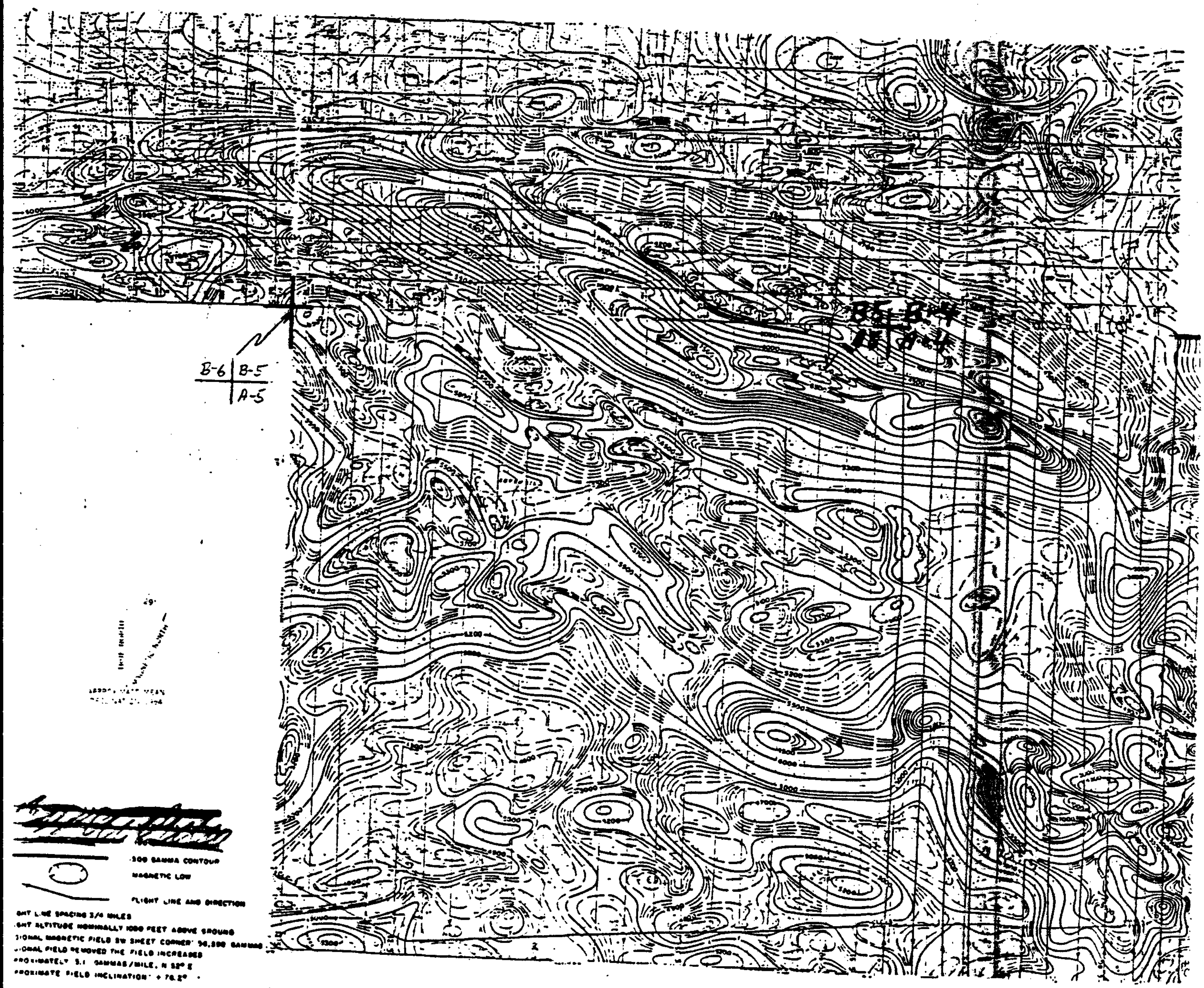
| Sample | Au | Pd | Pt |
|---|---|---|---|
| 4...... | 0.002 | ND | ND |
| 5...... | .002 | ND | ND |
| 16..... | .003 | ND | ND |
| 18..... | ND | ND | ND |
| 20..... | .001 | ND | ND |
| 22..... | ND | ND | ND |

ND - Not detected.

Draftsman

A. Show only the 500 γ contours

B. Use as a overlay for the topo in Fig 2 (base)




adapted from ... magnetic maps ... by the ... Geological Surveys (-) ... 1:25...

FIGURE 7 - ...
of the Fish Lake area

Figure 7. - Aeromagnetic survey of the Fish Lake area.

2,700 ft of northwest strike. If responses indicated on lines 'b', 'c', 'd', and 'e' are contiguous with the zone delineated on line 'a', the apparent strike length is then greater than 4,000 ft. A distinctive anomalous signature appears over a width of approximately 800 ft on both lines 'c' and 'd' indicating a magnetic zone beneath the surficial cover. However, this is tenuous since only a few reconnaissance lines were traversed. The small outcroppings of Sz to the southeast of line 'b' may also be continuations of this zone which would give a strike length of 5,300 ft.

A notable anomaly on the northern end of line 'd' is interpreted as a similar, although poorly exposed, zone of magnetite concentration. This anomaly occurs at a lower elevation where vegetation and talus cover is more extensive and since only one line traverses the zone, no estimate of strike direction can be made.

## CONCLUSIONS

The Fish Lake complex of serpentinized ultramafic rocks contain low-grade, chromic magnetite deposits. The magnetite is ubiquitous (up to 5 pct) as disseminations in less altered peridotite while higher magnetite concentrations (10 to 30 pct) can be found in magnetite stockwork zones within serpentinite. Northwest-trending magnetite stockwork zones are subparallel to the regional thrust faults, as well as to the layering within the Fish Lake Complex.

A reconnaissance magnetometer survey coupled with geologic observations indicate these zones may extend along strike from 4,000 ft to possibly 5,300 ft or more and vary from 200 ft to 800 ft in width. Additional stockwork zones may occur under the covered areas immediately north of these mapped zones.

The magnetite stockworks are easily traced over covered terrain using a magnetometer.

Chip samples averaged 12.9 pct $Fe_3O_4$ and 0.27 pct chromium. Locally, the magnetite concentration ranged up to approximately 30 pct. Davis tube separations encountered some losses of magnetite in the tailings due to the fine grain size and indicate finer grinding is necessary for liberation. Magnetite recovery averaged 63 pct at a grind size that passed 150 mesh. Finer grinding should also permit improved recovery and concentrate grade. Magnetite concentrates contained an average of 58 pct magnetite and 1.2 pct chromium, indicating a concentration ratio of 1:4.5 for $Fe_3O_4$ and 1:4.4 for chromium. The similar ratios indicate a solid solution of chromium in iron spinel which can be termed a chromic magnetite.

Ultramafic bodies of the Fish Lake Complex outcrop along a trend of at least 20 miles. Geologic structure and a strong aeromagnetic signature indicate good potential for additional low-grade magnetite mineralization under covered areas at Fish Lake and in other ultramafic bodies of the Fish Lake Complex. Emphasis of any future investigations should be directed toward the particularly strong aeromagnetic anomaly east of Fish Lake. Although these deposits represent a resource, the grade of mineralization is too low to be of any present or foreseeable future economic interest.

REFERENCES

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2. Stout, J. H. Geology of the Eureka Creek Area, East Central Alaska Range. AK Div. Geol. and Geophysical Surv., Geol. Rep. 46, 1976, 32 pp., 1 plate.

3. Alaska Division of Geological and Geophysical Surveys. Aeromagnetic Survey - East Alaska Range, Mt. Hayes (A-4 to A-6, B-4 to B-6) Quadrangle. Aeromagnetic series, 1973, 1:63,360 scale.

4. Nokleberg, W. J. Geologic Map of the Southern Part of the Mt Hayes Quadrangle, Alaska. U.S. Geol. Surv. OFR 82-52, 1982, 26 pp., 1 plate.

## APPENDIX. -- SAMPLE INDENTIFICATION KEY.

| Sample | Field no. |
|---|---|
| 1..... | AK12393 |
| 2..... | AK20648 |
| 3..... | AK18713 |
| 4..... | AK20649 |
| 5..... | AK20647 |
| 6..... | AK20256 |
| 7..... | AK20257 |
| 8..... | AK20650 |
| 9..... | AK18712 |
| 10.... | AK18711 |
| 11.... | AK18710 |
| 12.... | AK18709 |
| 13.... | AK18708 |
| 14.... | AK18707 |
| 15.... | AK20645 |
| 16.... | AK20646 |
| 17.... | AK20636 |
| 18.... | AK20644 |
| 19.... | AK20654 |
| 20.... | AK20655 |
| 21.... | AK20652 |
| 22.... | AK20653 |

# LIST OF CAPTIONS